DUAL LONG-TAILED PAIR/DOUBLE-BALANCED MODULATOR

GENERAL DESCRIPTION

The TCA240 is a bipolar integrated circuit comprising two long-tailed pairs with current sources. The circuit may be connected to form a double-balanced modulator. It features great flexibility and the excellent matching and temperature tracking of the transistors in the circuit makes it suitable for applications that are not possible with discrete components.

The circuit is especially suited for the following applications:

- modulator
- mixer
- switch or chopper
- AM synchronous demodulator
- FM quadrature demodulator
- phase comparator
- differential amplifier

QUICK REFERENCE DATA

Supply voltage at C1, C2, C5 and C6	V_C	max.	16 V
Emitter current (each transistor)	$-I_E$	max.	10 mA
D.C. current gain at $-I_E$ = 750 μA	h_{FE}	min.	23
Base-emitter voltage difference between transistors at I_{tail} = 1,5 mA	$\lvert\Delta V_{BE}\rvert$	max.	2,5 mV
Cut-off frequency (3 dB point)	f_{co}	typ.	34 MHz
Noise figure at f = 100 MHz; I_C = 1 mA	F	max.	3,7 dB
Operating ambient temperature range	T_{amb}	−20 to + 70	°C

PACKAGE OUTLINE

TCA240: 16-lead DIL; plastic (SOT-38).
TCA240D: 16-lead mini-pack; plastic (SO-16; SOT-109A).

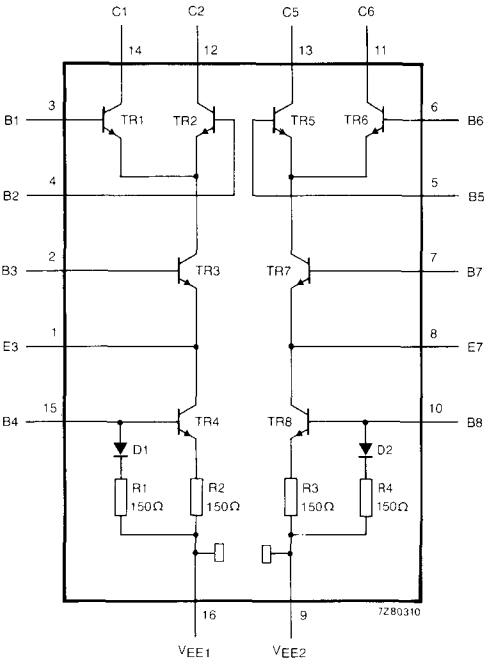

Fig. 1 Circuit diagram.

Pins 9 and 16 are both connected to the substrate. When both long-tailed pairs are used these pins should be interconnected externally.

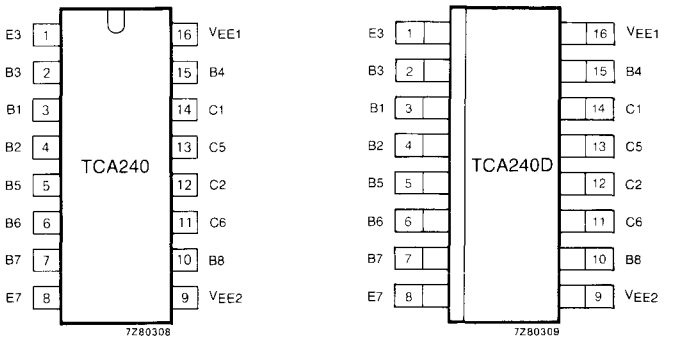

Fig. 2 Pinning diagrams.

FUNCTIONAL DESCRIPTION

The TCA240 contains two long-tailed pairs, each with a current source and a series transistor in the tail.

The current sources contain a current mirror. The tail current will be equal to the current flowing into pin 15 (10) with a deviation of less than 5%.

The TCA240 may be used as two long-tailed pairs or as a single double-balanced modulator. When used as two long-tailed pairs the tail currents may be adjusted separately. V_{EE1} and V_{EE2} (pins 9 and 16) should be interconnected and E3 and E7 (pins 1 and 8) should be left open. Transistors TR3 and TR7 reduce the influence of the long-tailed pair on the tail current.

When the circuit is used as a single double-balanced modulator only one current source is required. E3 and E7 (pins 1 and 8) should be interconnected and B8 and V_{EE2}, pins 10 and 9 (or B4 and V_{EE1}, pins 15 and 16) should be left open. TR3 and TR7 form a long-tailed pair now, each with a long-tailed pair at its collector.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-substrate voltage (open base and emitter)	V_{CSO}	max.	16 V
Collector-base voltage (open emitter)	V_{CBO}	max.	16 V
Collector-emitter voltage (open base)	V_{CEO}	max.	12 V
Base-emitter voltage (open collector)	$-V_{BEO}$	max.	5 V
Emitter current (each transistor)	$-I_E$	max.	10 mA
Base current (each transistor)	I_B	max.	10 mA
Total power dissipation (see also Fig. 3)	P_{tot}	max.	500 mW
Storage temperature range	T_{stg}	−55 to + 125	°C
Operating ambient temperature range	T_{amb}	−20 to + 70	°C

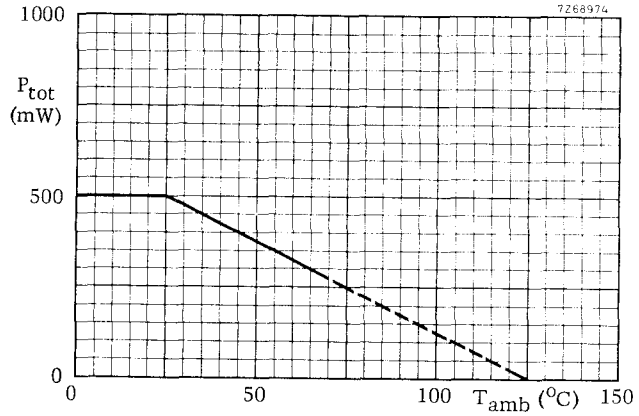

Fig. 3 Power derating curve.

CHARACTERISTICS

at $V_{C1} = V_{C2} = V_{C5} = V_{C6} = 12$ V;
$V_{B1} = V_{B2} = V_{B5} = V_{B6} = 6$ V;
$V_{B3} = V_{B7} = 4$ V; $V_{EE1} = V_{EE2} = 0$ V;
$T_{amb} = 25$ °C; unless otherwise specified

parameter	symbol	min.	typ.	max.	unit
Transistors TR1, TR2, TR5 and TR6					
D.C. current gain, each transistor, at $-I_E = 750\ \mu A$	h_{FE}	23	–	190	
Relative d.c. current gain difference of transistors TR1 and TR2 at $I_{E1} + I_{E2} = -1{,}5$ mA	$\frac{h_{FE1}-h_{FE2}}{h_{FE1}+h_{FE2}} \times 200$	−60	0	+60	%
Relative d.c. current gain difference of transistors TR5 and TR6 at $I_{E5} + I_{E6} = -1{,}5$ mA	$\frac{h_{FE5}-h_{FE6}}{h_{FE5}+h_{FE6}} \times 200$	−60	0	+60	%
Base-emitter voltage difference between TR1 and TR2 (TR5 and TR6) at $I_{tail} = 1{,}5$ mA	$\lvert\Delta V_{BE}\rvert$	–	–	2,5	mV
D.C. current gain of the parallel connection of TR1 and TR6 (TR2 and TR5) at $I_{tail} = 3$ mA	h_{FE1+6}, h_{FE2+5}	23	–	190	
Relative d.c. current gain difference of the parallel connection of TR1, TR6 and TR2, TR5 at $I_{tail} = 3$ mA	$\frac{h_{FE1+6}-h_{FE2+5}}{h_{FE1+6}+h_{FE2+5}} \times 200$	−60	0	+60	%
Base-emitter voltage difference between the parallel connection of TR1, TR5 and TR2, TR6 at $I_{tail} = 3$ mA	$\lvert\Delta V_{BE}\rvert$	–	–	2,1	mV
Transistors TR3 and TR7					
D.C. current gain, each transistor, at $I_{tail} = 3$ mA	h_{FE}	23	–	190	
Relative d.c. current gain difference of transistors TR3 and TR7 at $I_{tail} = 3$ mA	$\frac{h_{FE3}-h_{FE7}}{h_{FE3}+h_{FE7}} \times 200$	−60	0	+60	%
Base-emitter voltage at $-I_E = 1$ mA	V_{BE}	690	–	770	mV
Transistors TR4 and TR8					
Collector current difference at $I_{B4} = I_{B8} = 1{,}5$ mA	ΔI_C	–	–	0,07	mA

parameter	symbol	min.	typ.	max.	unit
Cut-off frequency					
3 dB point at I_{tail} = 5 mA; R_C = 600 Ω; see test circuit Fig. 4	f_{co}	–	34	–	MHz
Noise figure					
at f = 100 MHz; I_C = 1 mA; V_{CB} = 5 V; G_s = 3,7 mA/V; $-B_s$ = 2,5 mA/V	F	–	–	3,7	dB
at f = 100 MHz; $-I_E$ = 2,5 mA; V_{CB} = 5 V; G_s = 6,5 mA/V; $-B_s$ = 2,5 mA/V	F	–	–	4,2	dB

y parameters

at V_{CE} = 5 V; f = 100 MHz

		$-I_E$ =		1	5	mA
Input conductance		g_{ie}	typ.	4,4	13,6	mA/V
Input susceptance		b_{ie}	typ.	7,6	9	mA/V
Feedback admittance		$\|y_{re}\|$	typ.	0,4	0,4	mA/V
Phase angle of feedback admittance		$-\varphi_{re}$	typ.	100°	100°	
Transfer admittance		$\|y_{fe}\|$	typ.	22	55	mA/V
Phase angle of transfer admittance		$-\varphi_{fe}$	typ.	45°	96°	
Output conductance		g_{oe}	typ.	0,4	0,5	mA/V
Output susceptance		b_{oe}	typ.	1,8	18	mA/V

Switching times

(See test circuit, Fig. 5)

	I_{tail} =		0,5	1	2	4	mA
Rise time	t_{TLH}	typ.	2,9	2,7	2,7	3,1	ns
Fall time	t_{THL}	typ.	1,4	1,3	1,6	2,1	ns
Rise propagation delay time	t_{PLH}	typ.	1,1	1,1	1,4	1,7	ns
Fall propagation delay time	t_{PHL}	typ.	1,1	1,2	1,4	1,7	ns

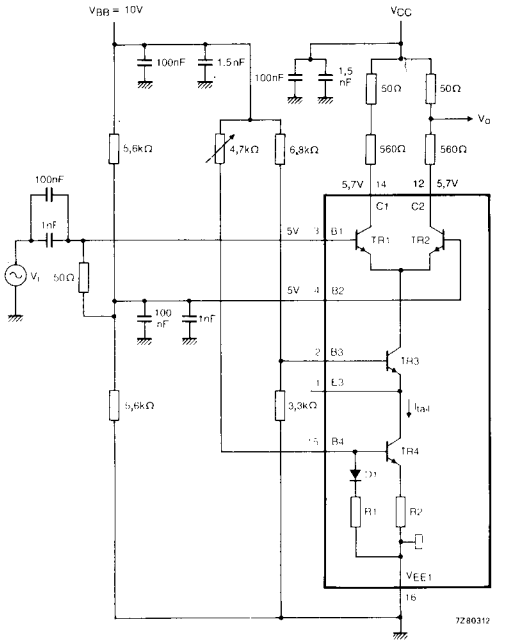

Fig. 4 Test circuit for the frequency response, shown for one half of the circuit.

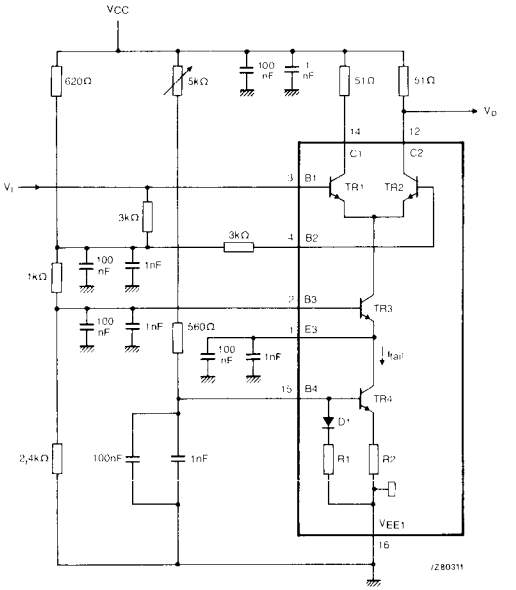

Fig. 5 Test circuit for the switching times, shown for one half of the circuit.

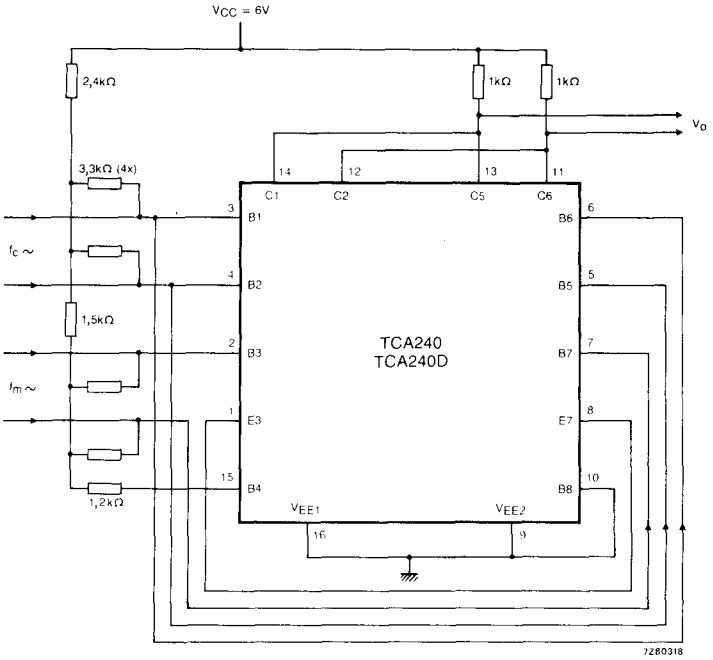

Fig. 6 Typical application of the TCA240 as a double-balanced AM modulator with suppressed carrier.

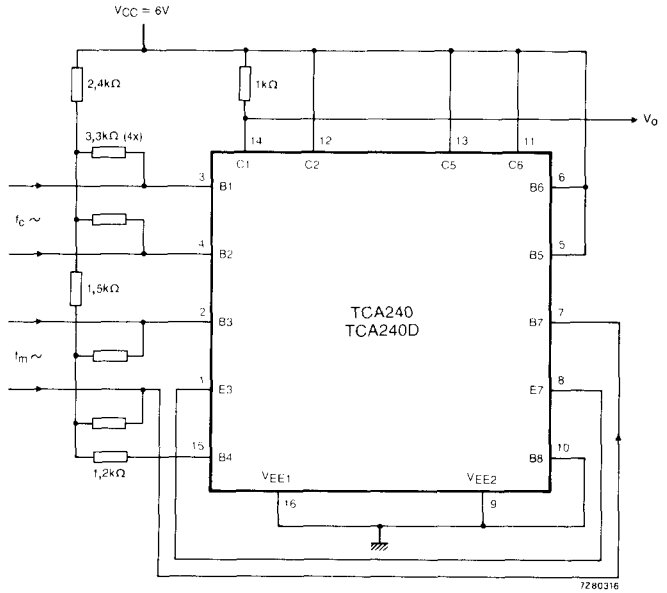

Fig. 7 Typical application of the TCA240 as an AM modulator.

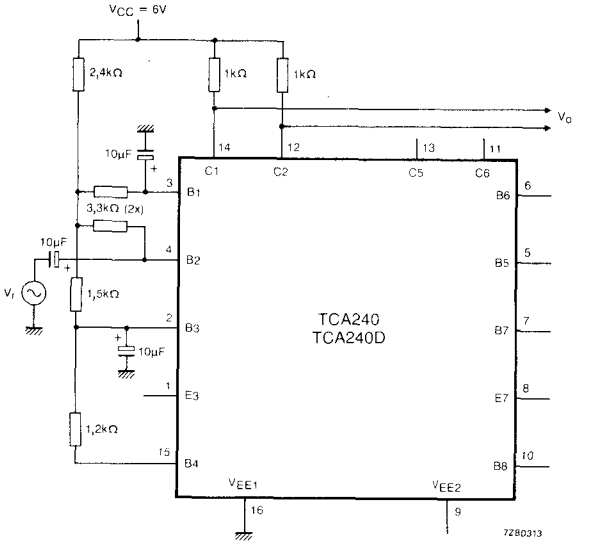

Fig. 8 Typical application of the TCA240 as a differential amplifier.

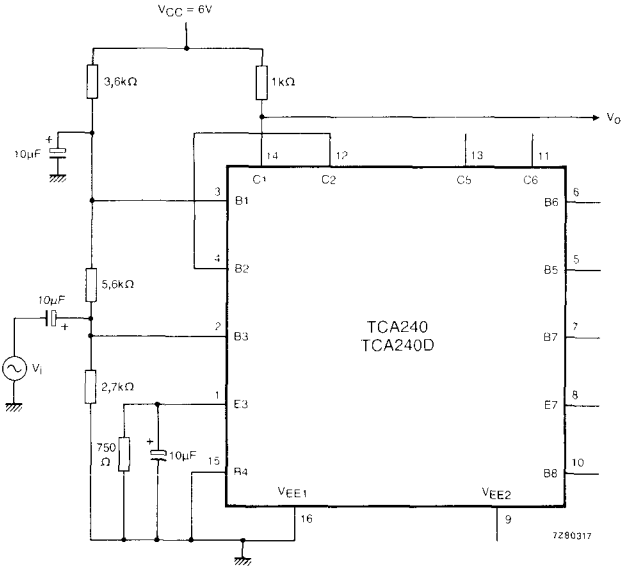

Fig. 9 Typical application of the TCA240 as a cascode amplifier.

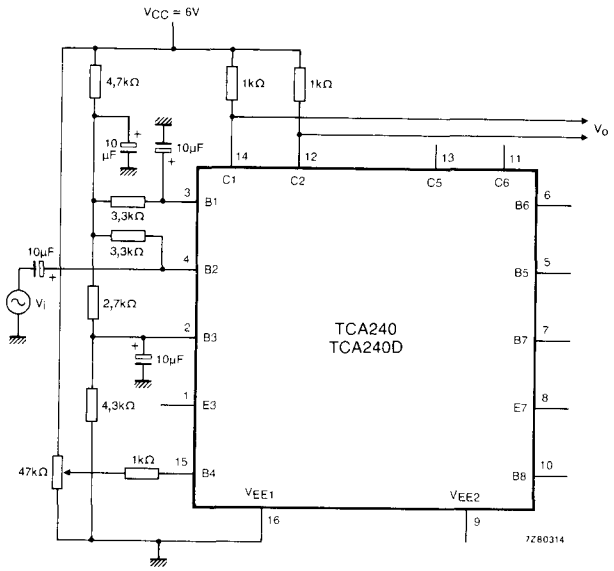

Fig. 10 Typical application of the TCA240 as a differential amplifier with gain control.

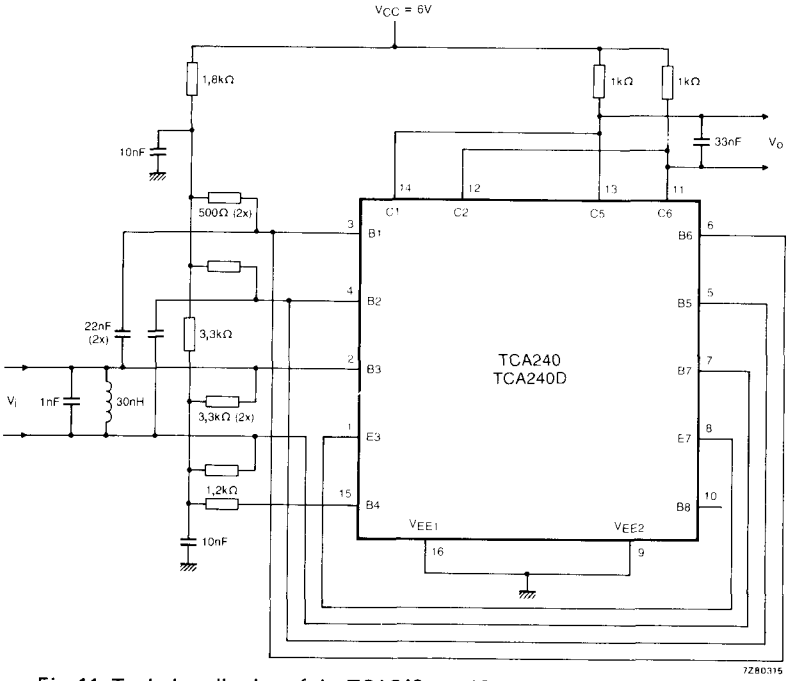

Fig. 11 Typical application of the TCA240 as a 10,7 MHz double-balanced FM demodulator.